HISTORY OF THE THEORIES OF THE WINDS, FROM THE EARLIEST TIMES TO THE BEGINNING OF THE SEVENTEENTH CENTURY.

551.55

By EDGAR W. WOOLARD.

[Weather Bureau, Washington, D. C., Sept. 6, 1921.]

Meteorology as a science is young, but as a branch of knowledge it is very old, perhaps as old as mankind; the beginnings of meteorology are to be found with the origins of civilization. Meteorological phenomena must have been among the first natural occurrences to be noted by primitive man; and most prominent among these are the winds.

In remote times man living as a hunter or agriculturist, mostly in the open, was more influenced by, and more dependent on, the weather than we are ourselves at present; and he was therefore forced to watch atmospheric phenomena closely. He did so, of course, not in order to study the atmosphere and to discover its laws, but to derive immediate advantages for himself. He was anxious to learn how to protect his house against the weather; how to foresee coming atmospheric conditions so that he might best plan his activities; and how to find out the most favorable climatic situations for various purposes. The experience of the more intelligent in these respects was handed down, and at the same time augmented from generation to generation, and very early formed an essential element in the knowledge of all races of mankind. For example, weather lore and weather superstitions existed among the Chaldeans and the Babylonians two or three thousand years before the Christian era;[1] and the winds came in for a large share of attention.

The Babylonians had the wind rose of eight rhumbs, and used the names of the four cardinal points to denote the intermediate directions.[2] The Greeks and the Romans gave to each wind its own peculiar name, a practice still in use among Italian mariners in the Mediterranean.

All early science was essentially of a purely observational or *descriptive* nature. In meterology, as in so many other fields, the Greeks, who played such a strong part in the development of all organized knowledge, were the first to attempt *theories* to account for the observed phenomena; however, early theoretical science was largely in the nature of arbitrary philosophical speculation; and the appeal was to authority rather than to experiment.

The Greeks were also the first to establish regular meteorological observations; observations of the winds prevail over all others, for they were of practical use to navigation and were easily made. The origin of the winds was always a favorite subject of speculation among philosophers. In the epoch of Homer (10th century B. C.?) the winds were still conceived of as absolute beings like gods. Anaximander of Ionia (5th century B. C.) was the first to give a scientific definition of the wind, and it is still valid: *The wind is a flowing of air.*

Since the time of the oldest philosophical school, that of Ionia (6th and 5th centuries B. C.), there have been few Greek philosophers who were not interested in some branch of meteorology. The subject then covered a wider field of research than at present, embracing, besides meteorology in the modern sense, also a good deal of physical geography and astronomy, especially shooting stars, meteors, and comets; the favorite meteorological subjects of speculation and reasearch seem to have been the origin of the winds, the theory of rain, and the rainbow.

Hippocrates (*b.* 460 B. C.), the "Father of Medicine," first enunciated the principles of public health in his treatise on *Airs, Waters, and Places*,[3] which included a consideration of the effects of winds. At an early period the Greeks used wind vanes, the "Tower of the Winds" at Athens,[4] constructed about the first century B. C., and still standing, affords interesting evidence of this. At that same time a contemporary Roman writer, Terentius Varro, tells us that in Roman villas wind vanes were constructed in such a manner as to show the direction of the vane on a wind rose fixed to the ceiling of the room. Yet no Greek or Roman word for wind vane has been handed down to us.

A good many cosmological speculations were put forward by the meteorologists, too, which often proved false, and, considered from a practical point of view, in all cases rather useless, whence in the period of Socrates (*b.* 470 *ca.* B. C.) meteorology itself came into disrepute; the Greeks had coined the word μετεωρόλογος, from μετέωρα, *supra-terrestrial*, and λόγος, *description* or *treatise*, to designate this branch of philosophy, and now a new word was formed, μετεωρολέχης, signifying a mean babbling about sublime things. Nevertheless, meteorology made real progress; and a century later, about 350 B. C., the first treatise on meteorology, τὰ μετεωρολογικά, was written by the great Greek philosopher Aristotle (384–322 B. C.).

Aristotle's work contains a great deal of miscellaneous information of mixed value.[5] The section which deals with the winds forms one of the best parts of the book. Aristotle adopted the Greek view of the sphericity of the earth,[6] and regarded the globe as surrounded by successive envelopes of the other "elements," water, air, and fire. Although he laid down very excellent principles for scientific investigation, seemingly being the first to appreciate fully the importance of obtaining observational data before drawing conclusions, his own practical application of the method was defective, and his results not uniformly trustworthy.

---

[1] See G. Hellmann: The Dawn of Meteorology. *Quar. Jour. Roy. Met. Soc.*, 34: 221–232, 1908.

[2] A device formerly attributed to Charles the Great (742–814 *ca.*) or to the monk Alcuin.

[3] This work went through a number of editions and translations in later times. See, e. g., *Hippocrates on Airs, Waters, and Places*, the received Greek text of Littré, with Latin, French, and English translations by eminent scholars. London, Wyman & Sons, 1881. See also Hippocrates, *Opusculum repertorii prognosticon in mutationes aeris tam via astrologica quam meteorologica ufi sapientes experientia comperientes voluerunt perquam utillissime ordinatum incipit sidere felici et primo probemium.* A Petro de Albano in Latinum traductus. Venetiis, 1485. Herodotus (484–425 B. C.) wrote on the local winds of Egypt in his "Euterpe." The first edition of his works was in Latin, by Laurentius Valla, Venice, 1474; *cf. Herodotus*, tr. by Wm. Beloe, 4 vols., Philadelphia, 1814.

[4] See Hellmann, *op. cit.* The development of the meteorological ideas of the Greeks from the time of Homer is very fully treated in: Otto Gilbert, *Die meteorologischen theorien des griechischen altertums.* Leipzig, 1907.

[5] A complete bibliography of the editions and translations of Aristotle's *Meteorologica* is given by G. Hellmann, Beiträge zur Geschichte der Meteorologie, Band II, No. 6, pp. 1–45. *Veröff. d. Kon. Preuss. Met. Inst.*, No. 296, Berlin, 1917.

[6] The majority of the ideas of ancient races regarding the form and size of the earth, and the general scheme of cosmography into which they fitted the atmosphere, are valuable only as curiosities; here, too, the Greeks first held correct and scientific ideas. Astronomy, as originally introduced into Greece from Egypt by Thales (640–546 B. C.) of the Ionian school and by others, was a science of observation pure and simple. Later, Pythagoras (569?–490? B. C.) advanced the theory that the earth, in common with other heavenly bodies, is a sphere, and that it rests without support in the center of the universe; it is extremely doubtful whether he had any real evidence in support of his view, but the belief in the spherical form of the earth never disappeared from Greek thought, and in later times was an established part of the Greek systems (probably because of the affection which the Greeks always seem to have had for the circle and the sphere as being "perfect" bodies), being maintained by most of the later philosophers: the well-known proofs based on the change of altitude of the celestial pole with change of latitude, and the disappearance of the hulls of ships before that of the masts, were brought out by Aristotle and by Pliny (23–79 A. D.), respectively; Eratosthenes (275–194 B. C.) executed an actual measurement of the earth based on the first principle. Eratosthenes, Polybius, and Strabo were acquainted with the general distribution of temperature over the earth and its cause.

The atmosphere, according to Aristotle, is continually being traversed by two kinds of "exhalations" from the earth—an essentially watery vapor, and a peculiar, essentially dry, smoke-like exhalation from dry earth. Both are raised by the heat of the sun, and are always associated together. Unlike some ancient philosophers, Aristotle did not believe that air when in motion was wind, while the same air condensed was rain. He believed that rain originates from the vaporous exhalation and wind from the dry exhalation; he was influenced by observations showing that during dry years, when the dry and smoke-like exhalation was most abundant, winds were most frequent, while the vaporous exhalation was most abundant during wet years. Aristotle knew that winds were due to the action of solar heat, but beyond this his views on their production were untrustworthy.

Meteorology is essentially the physics of the air; but the physics and mathematics of this period were, of course, most rudimentary. Like most of other ancient philosophers, Aristotle's ideas about the composition of the atmosphere were very crude; air was usually considered to be an element; it is difficult to understand what he considered the dry exhalation to be, but it is probable that it was hot air mingled with humic and other effluvia rising from the hot earth. It is interesting to note that in the Aristotelian work *De Mundo* (probably not written by Aristotle), *c.* 4, 394, it is stated that wind is nothing else but a large quantity of compressed air in motion. Aristotle does not specifically state that winds are due to a disturbance of the equilibrium of the air, although he comes very close to it. (There was no knowledge of mechanics at that time; the first ideas about statics were put forward by Archimedes (287–212 B. C.) in his work on fluid pressure, and nothing more of any consequence in either statics or dynamics was accomplished until the beginning of the seventeenth century.[7])

Over most of the globe nothing seems so fickle and irregular—so subject to the whims of chance—as wind direction and speed. The conspicuous exceptions to this rule were early taken note of: The monsoons, or seasonal winds, of the Indian Ocean have been known since antiquity. Aristotle includes a description of them, and of the periodic winds of Greece, giving the characteristics of each. The great military expedition of Alexander the Great (356–323 B. C.) brought to the Greeks considerable knowledge of the monsoon winds.[8]

There is but little to record for the next 2,000 years. Aristotle's system of philosophy completely dominated all thought. His successors, such as Theophrastus (374 ?–287 B. C.),[9] Posidonius (*c.* 150–30 B. C.), et al., added little or nothing; but numerous commentaries and paraphrases were published. Among the Romans but little was done;[10] and during the Dark Ages meteorology was barely kept alive. The revival of learning at the end of the twelfth century saw only a firm and absolute adherence to the doctrines of Aristotle,[11] although some authors[12] did add opinions of their own, or of others.

The beginnings of experimental science are to be found just at that epoch when scholasticism had reached its highest point, namely, in the thirteenth century. It probably took its origin contemporaneously in France and in England, where the two friends Pierre de Maricourt (Petrus Peregrinus) and Roger Bacon (1214–1294) can be considered as the first great representatives of the new aims. Systematic meteorological observations began to make their appearance.

The knowledge of the Greeks had practically all been lost during the Dark Ages.[13] When, in the fifteenth century, the first beams of light broke in upon the darkness, and men began again to think about such things, here and there some asserted that the earth was not flat, but round; the voyage of Columbus, and the great explorations and geographical discoveries that quickly followed, convinced men that the earth is at least globular, and gave them some idea of its dimensions. These explorations were very fruitful in bringing to light many new facts of meteorology, and in introducing men to many new experiences in general.[14] A considerable amount of observational data began to be accumulated, and now and then summaries of it were undertaken. Peter Apianus, in his *Cosmographia*, 1524, gives a discussion of winds, with a chart of names, character, and distribution over the globe, in their application to navigation.

The first thorough exposition of the known distribution of winds over the Atlantic and the Pacific Oceans was brought out by the Spanish Jesuit José de Acosta in 1590;[15] the monsoons of the Indian Ocean, as mentioned above, had been known since antiquity;[16] the northeast trades were discovered by Christopher Columbus (1451 ?–1506) on his first voyage to America. Acosta, in agreement with the common belief at that time, attributed the regular easterly winds of the torrid zone (called *brisas* by the Spanish seamen) to a movement of the heavens about a stationary earth, in which the atmosphere partakes, but more slowly; the west and southwest winds of higher latitudes (*vendavales*) are modifications caused by ascending or descending currents.

The voyages of the great navigators of the sixteenth century sufficed to map out the Trades (so named by the English) quite completely, and furnished a fresh stimulus for meteorological observing in general. Descriptive literature dealing with the various occasional storms also began to appear.[17]

---

[7] Before the time of Galileo (1564–1642) it was commonly supposed, on the authority of Aristotle, that every body had a "natural place," and that its normal state was one of rest in that place: E. g., a stone was supposed to sink in water because its natural place was at the bottom of the water.

[8] See T. E. Lones. *Aristotle's Researches in Natural Science*, London, 1912, Chaps. I–II. There have been two English translations of Aristotle's *Meteorology*—Pargiter, London, 1745; and Taylor, London, 1807—but copies are scarce. An excellent French translation, by J. Barthélemy Saint-Hilaire, with notes and the *De Mundo*, appeared at Paris, 1863. The winds occupy chaps. iv–vi, incl., of Book II. A translation was in preparation by E. W. Webster, who was killed in the World War.

[9] See *Theophrastus of Eresus on Winds and on Weather Signs*, by J. G. Wood, London, 1894. The Aristotelian theory is postulated; and concurrent and consequent phenomena of the winds, rather than the origin of the winds themselves, form the topic of discussion; also in the Loeb Classical Library: Theophrastus, *Enquiry into Plants and Minor Works*, vol. ii, London, 1916. Tr. by Sir Arthur Hort.

[10] The extensive colonial possessions of the Romans occasioned the Romans to be the first to point out the difference between continental and maritime climate.

[11] *Cf.* Hellmann, Dawn of Meteorology, *loc. cit.*

[12] E. g. Albertus Magnus in his great meteorological works. See Theodor Schmitt *Die Meteorologie und Klimatologie des Albertus Magnus*, 1909.

[13] Except in Arabia, where, e. g., a measurement of an arc of the meridian was carried out during this period.

[14] A bibliography of all textbooks of Meteorology published from 1500 to 1914 is given by G. Hellmann, Beiträge zur Gesch. d. Met., Bd. II, Nr. 6, Entwicklungsgeschichte des meteorologischen Lehrbuches, pp. 67–133. *Veröff. d. Kon. Preuss. Met. Inst.*, Nr. 296, Berlin, 1917. All textbooks issued on the Continent till the end of the seventeenth century are exclusively based on Aristotle, but his influence in England was much less, although not so many treatises on meteorology were published in England before 1700. The following literature specially devoted to the winds is worthy of being listed: *Ein Hüebscher schoner Kalender mit etlicher zugehörung . . . und von den vier Winden und irer Natur. . . .* In fine: Getruckt zu Beuttlingen von Michel Greyffen-1480—Alkindus, Jacobus. *De pluviis, imbribus, et ventis, ac aeris mutatione.* Venice, 1507. *De temporum mutationibus, sive de imbribus nunquam antea excussus nunc vero per D. Jo. Hieronymum a Scaligiis emissus.* Paris, 1540.—Apianus, Peter. *Cosmographia.* Landshut, 1524, and many later editions.—Biondo (Blondus), M. A. *De ventis et navigatione.* Venice, 1546.—Magnus, Olaus. *De ventis:* in *Historia de gentibus septentrionalibus. . . .* Rome, 1555.—Breventano, Stefano. *Trattato dell'origine delli venti, nomi et proprietà, loro utile et necessario.* Venice, 1571.—Agrippa, Camillo. *Dialogo sopra la generazione de venti, baleni, tuoni, fulgori, fuimi, loghi, valli e montagne.* Rome, 1584.—Merkius, H. A., *De ventis incendi tempore orientibus.* Leipzig, 1587.—Damius, Friedrich. *De vento theses meteorologicae.* 1590.—Bonaventura, Franciscus. *De causa ventorum motus.* 1592. *Anemologiae pars prior, id est: De affectionibus, signis, causisque ventorum ex Aristotele, Theophrasto, ac Ptolemeo tractatus.* 1593.—Mirovski, Andreas. *Theoria ventorum.* Wurtemburg, 1596.—Romanus, Adrian. *Ventorum secundum recentiores distinctorum usus.* Wurtemburg, 1596.

[15] José de Acosta (1539–1600). *Historia natural y moral de la Indias.* Seville, 1590; Salamanca, 1589 (in Latin). *The Naturale and Morale Historie of the East and West Indies.* London, 1604.

[16] In his work, *Muhit*, on the navigation of the Indian seas, published in 1554, the Turkish literary seaman Sidi Ali (Katibi Rumi) gives the times of commencement of the monsoon for 50 different places.

[17] The following are also of interest: Paluanius, Fabricius. *Tractatus duo, alter de ventis, alter de terræ motu.* 1601.—Drebbel, Cornelius. *Een cort tractaet van de natuere der elementen, ende hoe sij veroorsaecken der wint, regen, bliren, donder, ende waeromme dienstich zijn.* Haarlem, 1604, 1621. Other editions in different languages, also.—Dissertations on the winds by Waldung, Welhamer, Werenberg, Scharlachius, Malapert, Wolfrum, Agerius, et al.—Schickard, Wilhelm. *Anemographia.* Tubingae, 1631.

Finally, the numerous events which were so greatly widening men's ideas and altering the prevalent conceptions of the world—the discovery of America, the circumnavigation of the globe and the other great exploring expeditions which followed, the overthrow of the Ptolemaic system of astronomy, et. al.—so helped to loosen the old foundations and to make plain the need for a new structure, that near the end of the sixteenth century a general reconstruction of all scientific ideas commenced. The Aristotelian writings and methods were bitterly assailed, and their influence commenced to wane. The new philosophy of Francis Bacon (1561–1626) was expounded in opposition to Aristotle's philosophy; the separate sciences became differentiated and classified, the scientific method emerged, and marked progress soon took place along both theoretical and experimental lines. Science in general, and meteorology in particular, entered upon a new era.[18]

UNUSUAL AURORA AT JUNEAU, ALASKA.

On the night of September 1, there occurred what is said by old residents to have been one of the most brilliant auroral displays that has been observed in Juneau in the last 20 years.

While the aurora began about 9 p. m. and continued until nearly midnight, it was most brilliant from 9:10 to 9:50 and from 11:35 to 11:55. The characteristic feature of the first period of brilliancy was a vivid band of white light, almost as bright as the full moon, that arched the sky from the western to the eastern horizon and about 5 degrees south of the zenith. This band varied in width, but averaged about 5 degrees. At frequent intervals there developed from it appendages of white light and weird shape, sometimes like "mare's tails" cirrus clouds and again like tongues of flame. Occasionally there would form on the northern side of the arch a wide appendage radiant with all the colors of the spectrum and that would shimmer in the most fascinating manner. These various appendages assumed form and disappeared gradually, and not with the rapidity that sometimes attends auroral formations. During the prevalence of the arch a faint glow of white light spanned the southern sky about azimuth 60 to 300, and with its crest at altitude about 40 degrees.

About 11:45, a long streamer of intense green shot from the southeast, extending past the zenith and curling and twisting like a whip-lash. Almost immediately further flashes appeared on the entire arc of horizon from southeast through north to west. These grew in brilliancy and depth of coloring, and soon had become so strong that their light caused the neighboring landscape to be clearly visible, objects at the far side of town, nearly a mile away, being distinguishable.

The display continued to increase in intensity until 11:55, when it ceased with an abruptness that was startling. As though the "current had been shut off," every indication of the aurora vanished almost instantly and there was no further display during the night so far as known.

Earth currents attending the phenomenon affected the submarine cable connecting Juneau and Sitka to such an extent that from 9:20 to 10:25 p. m. and from 11:40 to midnight, when cable service closes for the night, it was utterly impossible to transmit or receive messages.—*M. B. Summers.*

HEAVY RAINS AND FLOODS IN LUZON, PHILIPPINES, AUGUST, 1921.

By José Coronas, S. J.

[Weather Bureau, Manila, P. I., Sept. 14, 1921.]

Although not a single typhoon traversed the Island of Luzon during the month of August, several distant typhoons that passed to the north were the cause of heavy rains and consequent floods over the western part of Luzon, particularly toward the middle of the month. Considerable damage was done to several Provinces by these floods. Manila was also flooded on the 16th, the water reaching the height of 1 meter (3 feet) in several portions of the city.

Following is the monthly total rainfall for a few of our stations as compared with the normal for August:

Station.	Amount.		Difference from the normal.	
	Millimeters.	*Inches.*	*Millimeters.*	*Inches.*
Manila	1,000.8	39.40	+598.5	+23.56
Baguio	1,848.8	72.79	+638.7	+25.15
Laoag	1,244.1	48.97	+424.2	+16.70
Vigan	1,521.6	59.90	+802.5	+31.60
Iba	1,097.9	43.23	+ 97.4	+ 3.83

The maximum rainfall in 24 hours for the same stations was as follows:

Station.	Amount.		Date.
	Millimeters.	*Inches.*	
Manila	246.3	9.70	Aug. 15
Baguio	272.7	10.74	Aug. 14
Laoag	278.7	10.97	Aug. 19
Vigan	243.9	9.60	Aug. 20
Iba	195.0	7.68	Aug. 15

[18] *Cf.* Walter Libby. *An Introduction to the History of Science.* New York, 1917. In the preparation of this paper use has been made of: H. H. Hildebrandsson and L. Teisserenc de Bort, *Les Bases de la Météorologie Dynamique*, Tome I, Paris, 1907; G. Hellmann's *Neudrucke von Schriften und Karten über Meteorologie und Erdmagnetismus;* and the unpublished U. S. Signal Corps *Bibliography of Meteorology*, edited by O. L. Fassig, Part III, Winds Part IV, Storms.